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IS 11421 (1985): Techniques of pulsation for suppression for reciprocating compressors [MED 22: Compressor, Blowers and Exhausters]

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Indian Standard

(Reaffirmed 2001)

TECHNIQUES OF PULSATION FOR SUPPRESSION FOR RECIPROCATING COMPRESSORS

Compresssors Sectional Committee, EDC 62; Panel for Technical Supply Conditions for Various Air Compressor, EDC 62 : P2 [Ref : Doc : EDC 62 (4110)]

1. Scope — Lays down the techniques of pulsation suppression for reciprocating compressors.

2. Pulsation Suppression Devices

2.1 Pulsation suppression devices shall be furnished when specified by the purchaser. Two basic types of pulsation suppression devices are:

a) volume bottles (defined as empty vessels with a diameter of at least twice the diameter of the line connectors).

b) pulsation filters and attenuators, including proprietary commercial designs based on accoustical suppression techniques.

2.2 The purchaser shall specify the design approach for pulsation suppression. The three techniques normally used for the design of pulsation suppression devices are as follows:

a) *Design Approach 1* — Oversized piping for compressors of 110 kW power ratings and under, volume bottle, choke tube, or orifice systems designed using standard analytical techniques.

b) *Design Approach 2* — Pulsation suppression devices designed using proprietary techniques, with or without an acoustical analog piping analysis as specified.

c) *Design Approach 3* — Analog evaluation of any of the above, including study of mechanical and acoustical interaction of compressor components, suppression devices and the piping system.

2.2.1 Pulsation suppression devices in accordance with design approaches 1, 2 and 3 shall satisfy the following criteria:

a) Considering the applied steady state stresses, pulsation induced vibrations shall not cause cyclic stress levels in excess of the cyclic endurance limit of the the material used. For steel pipe below 370°C operating temperature, a value of 182·8 N/mm² peak-to-peak stress shall be used, with all other stresses within applicable code limits.

b) Unless other criterial based on loss in compressor efficiency are specified, peak-to-peak pulsation level (as a percentage of average absolute line pressure) at the compressor valves shall not exceed:

$$P_v = 8\left(\frac{R-1}{R}\right)^{0{\cdot}5}$$

where

P_v = percentage of maximum allowable peak-to-peak pulsation at compressor valves, and

R = stage pressure ratio.

c) Unless otherwise specified, at normal operating conditions the pressure drop through a pulsation suppression device shall not exceed the following percentage of the average absolute line pressure at the device:

$$\Delta P = \frac{1{\cdot}67\,(R-1)}{R}$$

where

P = the maximum pressure drop through a pulsation suppression device (expressed as a percentage of the absolute line pressure at the device), and

R = stage pressure ratio.

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d) Operating with abnormal gases or abnormal start-up conditions shall be specified on the data sheets. Pulsation suppression device shall be mechanically suitable for the specified conditions.

e) The peak-to-peak pulsation limitations specified in **2.2.1**, **2.4** and **2.5** shall apply to all operating conditions specified.

2.3 It is recommended that the purchaser specifies the pulsation suppression system design approach in accordance with Tables 1 and 2.

Note — Tables 1 and 2 are intended as a general guide and shall not be used without knowledgeable review for the specific service involved by qualified personnel.

a) For final discharge pressure under 70 bars or for driven power ratings under 370 kW, and when there is on anticipated interogation between adjacent machines (*see* Table 1).

b) For final discharge pressures of 70 bar and over, for driven power ratings of 370 kW or over, or for more than one machine discharging into or taking suction from the same piping system when interaction of pulsation is anticipated (including most compressors over 110 kW power ratings and operating in parallel) (*see* Table 2).

TABLE 1 PULSATION SUPPRESSION DESIGN APPROACH 'A'

Number ofStages	Recommended Design Approach		
	Single Cylinder	Two Cylinders	Three or More Cylinders
One	1	1	2
Two or More	—	3	3

TABLE 2 PULSATION SUPPRESSION DESIGN APPROACH 'B'

Number of Stages	Recommended Design Approach		
	Single Cylinder	Two Cylinders	Three or More Cylinders
One	2	2	3
Two or More	—	3	3

2.4 Pulsation suppression devices designed according to design approaches 1 or 2 (*see* **2.2**) shall limit the peak-to-peak pulsation levels at the lineside nozzle of the pulsation device to 2 percent of the line pressure or to a value calculated from the following formula, whichever is smaller:

$$P_1 \text{ (percent)} = \frac{10}{(14{\cdot}5\, P_L)^{1/3}}$$

where

P_1 (percent) = percentage of maximum allowable peak-to-peak pulsation (percentage of average absolute pressure), and

P_L = average absolute line-side pressure, in bar.

2.5 Analog evaluation for design approach 3 (*see* **2.2**) shall be accomplished with an active analog that simulates the entire compressor, pulsation suppression, devices, piping, and equipment system and considers dynamic interactions among these elements. In addition to the requirements stipulated in **2.2**, the following steps are required to accomplish the proper analog evaluation:

a) Determine the acoustical response of the system, including the amplitude and the spectral frequency distribution of pulsations. This analysis shall include the effect of dynamic interaction among cylinder, damper, and piping and the effect damper and piping interaction has on cylinder performance.

b) Determine the mechanical response of the piping system, including mechanical natural frequencies and node shapes of the compressor cylinder-manifold system. This analysis shall also establish allowable limits of pulsation-induced shaking forces based on the cyclic stress levels they may produce.

c) Determine the required pulsation suppression based on acoustical and mechanical responses and interactions. To obtain the desired pulsation control, selective use shall be made of both acoustical and mechanical control techniques. These include the elimination of coincidences between acoustical and mechanical resonances, the use of acoustical filtering techniques, and changes in mechanical configurations.

d) The peak-to-peak pulsation levels in the initial, suction, interstage, and final discharge piping systems shall normally be limited to that calculated by the following equation:

$$P_1\,(\text{percent}) = \frac{300}{\sqrt{0{\cdot}57\, P_L \times ID \times F}}$$

where

P_1 (percent) = percentage of maximum allowable peak-to-peak pulsation (percentage of average absolute line pressure),

P_L = average absolute line-side pressure, in bar,

ID = inside diameter of pipe, in mm, and

F = pulsation frequency (in hertz) derived from the following equation in which RPM is machine speed and $N = 1, 2, 3 \ldots \ldots$, corresponding to the fundamental frequency and harmonics thereof

$$F = \frac{RPM \times N}{60}$$

However, plusation limits within pulsation bottles may exceed this level if all requirements in **2.2** are satisfied.

2.6 Pulsation damping equipment shell be suitably designed and fabricated unless specifically asked by the purchaser.

2.7 The maximum allowable working pressure shall not be less than the safety relief valves setting.

2.8 The corrosion allowance for shell and internals shall be 3 mm, *Min*.

2.9 All welds shall have full penetration.

2.10 Welding shall be done by qualified welders. When specified, all welds shall be 100 percent radiographed.

2.11 Unless otherwise agreed upon, the main nozzle connection (cylinder side and line side) shall be reinforced by saddles. All other connections shall be reinforced with pad-type reinforcement providing a metal area equal to the cutaway area, regardless of the metal thickness present in the connection wall.

2.12 When specified, suction pulsation suppressors shall include a final moisture removal section as an integral part of the vessel. The moisture removal section shall have a reservoir extended below the suppressor shell and shall be equipped with a 25 mm minimum drain connection. If a separator is specified, it shall remove 99 percent of all droplets of 10 microns or larger.

2.13 The nozzle length from the pulsation suppressor shell to the cylinder flange shall be held to a minimum consistent with thermal flexibility and misalignment limitations. The nozzle area shall be at least equal to the area of the compressor opening. Adequate space shall be allowed for access to and maintenance of cylinder working parts. Suction pulsation suppressors shall be designed to prevent slugging of liquid into the cylinder under normal operating conditions.

2.14 Manufacturing tolerances and fit-up procedures in compressor cylinder nozzle pulsation suppressor connections shall be adequate to avoid excessive misalignment.

2.15 Orientation of the pulsation suppressors and their nozzles shall be specified by the purchaser, subject to practical limitations imposed by the supplier. Ratings, types and arrangements of all connections shall be agreed upon by the purchaser and the supplier.

2.16 Twenty-millimetres pressure test connections shall be provided at each pulsation suppressor inlet and outlet nozzle. A 25 mm minimum external drain connection shall be provided where practical for each compartment. Where drains are impracticable, circular notched openings in the bulkheads extending to the vessel wall may be used with the purchaser's approval. The effect of such drain openings on pulsation suppressor performance shall be considered. Arrangement of internals shall ensure that liquids shall flow to drain connections under all operating conditions.

2.17 The cylinder nozzle of each discharge pulsation suppressor shall be provided with two connections located to permit, without interference, the purchaser's installation of 25 mm minimum thermowells for high temperature alarm or shutdown element and a dial thermometer. When specified, a 25 mm minimum thermowell connection shall also be provided for the cylinder nozzle of each suction pulsation suppressor. Connections 55 mm and smaller shall be designed to minimize overhang weight and shall be suggested in at least two planes to avoid breakage due to pulsation-induced vibration.

2.18 All main connections to pulsation suppressors shall be flanged unless otherwise specified by the purchaser. 150 mm pad-type flanged inspection openings complete with blind flanges and gaskets, shall be provided for access to each compartment.

2.19 Construction shall be suitable for service in unprotected outdoor location. When specified, insulation clips shall be provided. All connections and nameplates shall be arranged to clear the insulation.

2.20 When specified by the purchaser, the supplier shall supply a support system for the pulsation suppressors.

2.20.1 Adjustable shall be provided when necessary and shall be adjusted for proper support of the unit at normal operating conditions.

2.20.2 The support shall not introduce excessive stresses in the frame or the compressor-manifold system.

2.20.3 The support foundation shall be integral with the compressor foundation.

2.20.4 The mounting plate for the support shall be anchored into the foundation.

2.20.5 Springs may be used for pulsation damper or piping supports if analysis indicated that they will not adversely affect system stress and vibration.

2.20.6 The pulsation suppressor shall not be used to support the compressor cylinder.

2.21 Fabrication drawings, including weld details, internal construction, internal and external drain details, and the like shall be submitted to the purchaser for review and approval.

EXPLANATORY NOTE

This standard lays down the techniques for sizing design evolution for pulsation suppression devices so as to ensure better performance. Also give a brief account of devices. These techniques and devices are applicable to all sizes of reciprocating compressors.

While preparing this standard assistance has been derived fron APD Standard 618 (*second edition*) July 1974 'Reciprocating compressors for second refinery reviews', issued by American Petroleum Institute (API).

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